

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**

PCTWORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : A61K 9/16, 9/50, 49/00	A1	(11) International Publication Number: WO 98/17257 (43) International Publication Date: 30 April 1998 (30.04.98)
(21) International Application Number: PCT/GB97/02875 (22) International Filing Date: 17 October 1997 (17.10.97) (30) Priority Data: 9621825.0 19 October 1996 (19.10.96) GB (71) Applicant: ANDARIS LIMITED [GB/GB]; 1 Mere Way, Ruddington, Nottingham NG11 6JS (GB). (72) Inventors: TURNBULL, Graham, John; 23 The Lane, Hauxton, Cambridge CB2 5HP (GB). OSBORNE, Nicholas, David; Andaris Limited, 1 Mere Way, Ruddington, Nottingham NG11 6JS (GB). (74) Agent: GILL JENNINGS & EVERY; Broadgate House, 7 Eldon Street, London EC2M 7LH (GB).		(81) Designated States: AL, AM, AU, AZ, BA, BB, BG, BR, BY, CA, CN, CU, CZ, EE, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, RO, RU, SD, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>
(54) Title: POROUS MICROCAPSULES AND THEIR USE AS THERAPEUTIC AND DIAGNOSTIC VEHICLES (57) Abstract Microcapsules that are porous have increased surface area. Therefore, increased loading of an associated physiologically or diagnostically-active component is possible, wherein at least a proportion of said component is present within the microcapsules and/or linked to the pores. Loading can be a factor of at least 2 greater than for corresponding non-porous microcapsules.		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav	TM	Turkmenistan
BF	Burkina Faso	GR	Greece		Republic of Macedonia	TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's	NZ	New Zealand		
CM	Cameroon		Republic of Korea	PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

POROUS MICROCAPSULES AND THEIR
USE AS THERAPEUTIC AND DIAGNOSTIC VEHICLES

Field of the Invention

5 This invention relates to porous microparticles and to their use as therapeutic and diagnostic vehicles.

Background of the Invention

10 WO-A-9618388 discloses spherical microparticles, 0.1-50 μm in diameter, of cross-linked material, the microparticles being hydrophilic and capable of reconstitution in water to give a mono-dispersed suspension. The microparticles additionally comprise a physiologically or diagnostically-active agent linked directly or indirectly to the microparticles via free functional groups thereon.

15 Such microparticles can be prepared as a result of the discovery that, while microparticles having very desirable physical characteristics can be obtained by controlled spray-drying techniques, those techniques do not substantially affect functional groups. Thus, despite the heating etc. used in spray-drying, a proteinaceous material
20 such as human serum albumin (HSA) retains functional groups such as OH, COOH, NH_2 and SH which, after cross-linking of the particles, are available for bonding to active agents. The bonded materials are useful for therapeutic or
25 diagnostic purposes, on account of the controlled particle size that can be obtained for the particles in the spray-drying procedure. Thus, for example, microparticles of a defined size can be used for the delivery of an appropriate drug, by means of a powder inhaler, to the alveoli.

30 A problem with this technology, for certain active materials, is that the amount that can be bonded to the particles is low. Further, cross-linking of the microparticles may reduce the number of available bonding sites. This problem may be relatively unimportant if the
35 agent is a highly potent drug, but even then the effect of a drug may be masked to an undesirable effect by the microparticles acting as its carrier to the site of action.

It is also possible that a predominant carrier may have a toxic effect, and/or may undesirably dictate drug release characteristics.

EP-A-0306236, EP-A-0466986, US-A-5008116, WO-A-
5 9104732, WO-A-9300050 and WO-A-9307862 disclose various types of generally solid porous polymeric particles containing active agent retained in the pores. The agent may thus be subject, for example, to controlled release.

US-A-5069936 discloses cross-linked protein
10 microspheres with controlled porosity, for a similar purpose. A biological agent is held on the surface and in the pores, to relative extents depending on the method of manufacture, and with a view to providing a desired degree of protection/presentation of the agent, in use.

15 Summary of the Invention

The present invention is based on the utility of porous microparticles, but specifically hollow microcapsules, and for a purpose different from controlled release. In particular, it has been discovered that the
20 loading of drugs on microcapsules, of the type that can be obtained by spray-drying, can be greatly enhanced. The loading can be increased by a factor of at least 2, 3 or more, relative to the level of loading that is possible in the absence of any modification according to the present
25 invention.

This and other desirable effects are achieved by rendering the walls of suitable microcapsules porous. The pores provide additional surface area, to which a physiologically or diagnostically-active agent can be
30 chemically or physically linked, in addition to surface binding. The porosity may also be used as a means to introduce the agent into the microparticles. It may also enhance biodegradability.

Description of the Invention

35 In general, products of the invention may be prepared by the steps of producing the microparticles, fixing/cross-linking them (if necessary or desired), rendering the

microparticles porous, and then introducing the added agent. The agent may be chemically or physically linked to, trapped in, or otherwise associated with, the microparticles.

5 The microparticles themselves are suitably prepared by spray-drying, e.g. using the materials and techniques described, for example, in WO-A-9218164, WO-A-9609814 and WO-A-9618388. These publications also describe desirable sizes and size distributions. WO-A-9609814 and WO-A-9618388 (incorporated herein by reference) also describe agents that can be coupled to the microparticles, and various means for doing that. Cytotoxic agents such as methotrexate, cisplatin and doxorubicin are examples of such compounds that can be used in accordance with this invention.

15 Rendering the microparticles porous can markedly increase their surface area, provided that the pores are of sufficient size to ensure wetting of the additional surface area. Further, the thicker the walls of the microcapsules, the more opportunity exists for providing advantages such as more bound drug, and fewer microcapsules per dose. Also, porous walls should increase the biodegradation rate *in vivo*, by allowing extracellular and intracellular enzymes access to a larger surface area for preliminary breakdown. In turn, that can accelerate overall breakdown and release of bound drug.

25 One way of rendering spray-dried microparticles more porous involves spray-drying the wall-forming material with an additional component that can subsequently be removed from the walls, e.g. by treating the formed microcapsules with a solvent for that component. Thus, for example, a solution or suspension of a sugar such as lactose or a salt such as calcium carbonate or magnesium carbonate in HSA (used herein merely as an illustrative wall-forming material) can be spray-dried to yield microcapsules which, after heat or chemical fixation, can be treated in an aqueous medium to remove the sugar or salt. Depending on

the particle size and on the loading of carbonate suspension, the porosity/pore size is controllable.

Likewise, a porous wall may be produced by co-spraying HSA with calcium alginate, heat-stabilising the microcapsules and, in an aqueous medium, removing the alginate by Na or EDTA.

To avoid exposing unstabilised microcapsules to an aqueous phase, there is the alternative of co-spraying HSA with, say, sodium benzoate, and suspending the resulting microcapsules in ethanol to remove the benzoate. This approach may also avoid the need to stabilise the microcapsules before removal of the temporary component. Co-spraying HSA and a lipid or wax (chosen for pharmaceutical acceptability), and removing the lipid in a pharmaceutically-acceptable organic solvent, also avoids the need to fix the capsule before removing the temporary component.

Porosity may also be introduced by chemical or physical treatment of intact microparticles, fixed or unfixed. A suitable physical process comprises high energy ultrasound exposure of microcapsules suspended in a concentrated drug solution. This results in passage of the drug in solution into the central cavity. Subsequent removal of the water by, for example, lyophilisation should leave the drug within the microcapsule.

Ultrasound treatment of the microcapsules in a non-aqueous solvent, or followed by rapid transfer to a solvent, may also increase greatly the concentration of the drug in the medium, and hence the drug load entering the microcapsule. In such a case, the solvent should be pharmaceutically-acceptable, such as ethanol. Other pharmaceutically-acceptable solvents for the drug (or vehicle for suspended drug) may include lipids, particularly natural dietary components and/or naturally circulating lipids such as palmitic acid. Certain waxes with low melting point might also be acceptable and effective as carriers for dissolved or suspended drug.

Retention of a vehicle such as palmitic acid within the microcapsule may be used to affect the *in vivo* drug release rate. In place of removing the vehicle by lyophilisation etc, a filtration or centrifugation step may be used, followed by a rapid solvent wash.

Microcapsules may be loaded with bound drug and then filled with unbound drug, to increase the total drug load. The half-life for *in vivo* release may be different for bound and unbound drug, providing a burst of released (unbound) drug, followed by slower release of bound drug.

The following Example illustrates the invention.

Example

HSA was spray-dried with 0% (control), 10% and 25% lactose. The microparticles containing lactose were then stabilised by the use of heat (H) or chemical cross-linking (X), half of each type were washed (W), and all were loaded with fluorescein isothiocyanate (FITC). In the following Table, therefore, "Lac 25 X W" refers to washed, chemically cross-linked microparticles containing 25% lactose. In each case, the results of 2 different runs are provided under "spec. Reading".

The data clearly indicate that increased loading is achieved by using lactose, especially if washing is used as an intentional means of removing it. In all cases, loading is increased by a factor of more than 2, with respect to the control.

Table

5	Sample	Spec. Reading ($\mu\text{m}/\text{ml}$)	Mean Number Of FITC Moles Bound
5	Lac 25 X W	0.9126/1.3406	10.33
	Lac 25 X	1.0813/0.8115	8.68
	Lac 25 H W	0.3508/0.4413	3.63
	Lac 25 H	0.3657/0.8008	3.51
10	Lac 10 X W	0.4357/0.3858	3.77
	Lac 10 X	0.3047/0.2178	2.39
	Lac 10 H W	0.0884/0.0940	0.84
	Lac 10 H	0.0804/0.1661	0.75
	HSA (control)	0.0440/0.0401	0.39

CLAIMS

1. Porous microcapsules.
2. Microcapsules according to claim 1, obtainable by co-spray-drying a wall-forming material and a material that
5 can be removed from the capsule walls, and removing said material.
3. Microparticles according to either preceding claim, which are cross-linked.
4. Microcapsules according to any preceding claim, 0.1 to
10 50 μm in size.
5. Microcapsules according to any preceding claim, which have an associated physiologically or diagnostically-active component, wherein at least a proportion of said component is present within the microcapsules and/or linked to the
15 pores in the walls of the microcapsules.
6. Microcapsules according to claim 5, wherein said component is chemically or physically linked.
7. Microcapsules according to claim 5, wherein said component is trapped.
- 20 8. Microcapsules according to any of claims 5 to 7, wherein the loading of the active component is a factor of at least two times that obtainable for the same size of non-porous microcapsules.
9. Microcapsules according to claims 8, wherein the
25 factor is at least 3 times.
10. Microcapsules according to any of claims 5 to 9, for use in therapy or diagnosis.

INTERNATIONAL SEARCH REPORT

International Application No
PC1/GB 97/02875

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 A61K9/16 A61K9/50 A61K49/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 306 236 A (ADVANCED POLYMER SYSTEMS, INC.) 8 March 1989 cited in the application see page 11 - page 12; example 3.1.1. ---	1-10
X	WO 93 07862 A (ADVANCED POLYMER SYSTEMS, INC.) 29 April 1993 cited in the application see page 10, line 3 - line 36 see page 33, line 38 - page 38, line 11 ---	1-10
X	WO 91 04732 A (ADVANCED POLYMER SYSTEMS, INC.) 18 April 1991 cited in the application see the whole document ---	1-10
-/--		

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

23 January 1998

Date of mailing of the international search report

03/02/1998

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Benz, K

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/02875

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 466 986 A (BEND RESEARCH, INC.) 22 January 1992 cited in the application see page 4, column 6, line 32 - line 53 see page 5, column 8, line 10 - line 36 ----	1-10
X	US 5 069 936 A (YEN) 3 December 1991 cited in the application see column 5, line 29 - line 38 see column 11, line 34 - line 45 ----	1-10
X	US 5 008 116 A (CAHN) 16 April 1991 cited in the application see the whole document ----	1-10
A	WO 93 00050 A (GENETICS INSTITUTE, INC.) 7 January 1993 cited in the application see page 6, line 22 - page 7, line 27 see page 10 - page 18; examples 1-4 ----	1-10
A	WO 96 18388 A (ANDARIS LIMITED) 20 June 1996 see the whole document ----	1-10
A	WO 96 09814 A (ANDARIS LIMITED) 4 April 1996 cited in the application see the whole document ----	1-10
X	DATABASE WPI Week 8849 Derwent Publications Ltd., London, GB; AN 88-348733 XP002053077 & JP 63 258 640 A (LION CORP) , 26 October 1988 see abstract ----	1
X	DATABASE WPI Week 8939 Derwent Publications Ltd., London, GB; AN 89-282482 XP002053078 & JP 01 207 133 A (MATSUMOTO YUSHI SEIYAKU KK) , 21 August 1989 see abstract ----	1
X	EP 0 076 515 A (TANABE SEIYAKU CO., LTD.) 13 April 1983 see the whole document -----	1,2,4,5, 7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 97/02875

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 306236 A	08-03-89	AU 2164088 A	23-03-89
		DE 3880593 A	03-06-93
		DE 3880593 T	21-10-93
		JP 1131112 A	24-05-89
		KR 9613701 B	10-10-96
		US 5145675 A	08-09-92
WO 9307862 A	29-04-93	AU 662181 B	24-08-95
		AU 2881592 A	21-05-93
		CA 2121687 A	29-04-93
		EP 0612241 A	31-08-94
		JP 2516322 B	24-07-96
		JP 7500596 T	19-01-95
WO 9104732 A	18-04-91	AT 131726 T	15-01-96
		AU 646414 B	24-02-94
		AU 6715690 A	28-04-91
		CA 2066594 A	04-04-91
		DE 69024363 D	01-02-96
		DE 69024363 T	04-07-96
		EP 0494996 A	22-07-92
		ES 2083467 T	16-04-96
		JP 5500959 T	25-02-93
EP 466986 A	22-01-92	CA 2014595 A	12-10-91
		DE 69008526 D	01-06-94
		DE 69008526 T	18-08-94
		ES 2053120 T	16-07-94
US 5069936 A	03-12-91	NONE	
US 5008116 A	16-04-91	NONE	
WO 9300050 A	07-01-93	AT 142460 T	15-09-96
		AU 663328 B	05-10-95
		AU 2254292 A	25-01-93
		CA 2111199 A	07-01-93
		DE 69213739 D	17-10-96
		DE 69213739 T	20-02-97
		EP 0591392 A	13-04-94

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 97/02875

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9300050 A		ES 2094359 T JP 6508777 T MX 9203083 A NO 934573 A US 5597897 A	16-01-97 06-10-94 31-08-94 13-12-93 28-01-97
WO 9618388 A	20-06-96	AU 4184996 A CA 2207077 A EP 0796090 A FI 972546 A NO 972554 A PL 321018 A	03-07-96 20-06-96 24-09-97 04-07-97 05-06-97 24-11-97
WO 9609814 A	04-04-96	AU 3530295 A CA 2199954 A EP 0783298 A FI 971332 A NO 971438 A PL 319600 A	19-04-96 04-04-96 16-07-97 01-04-97 26-03-97 18-08-97
EP 76515 A	13-04-83	JP 1449145 C JP 58058145 A JP 62059625 B	11-07-88 06-04-83 11-12-87